(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 017 250 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication:
05.07.2000 Bulletin 2000/27

(21) Application number: **99926839.4**

(22) Date of filing: **29.06.1999**

(51) Int. Cl.[7]: **H04R 3/00**

(86) International application number:
PCT/JP99/03502

(87) International publication number:
WO 00/02416 (13.01.2000 Gazette 2000/02)

(84) Designated Contracting States:
DE FR GB

(30) Priority: **01.07.1998 JP 18597398**

(71) Applicant:
MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.
Kadoma-shi, Osaka-fu 571 (JP)

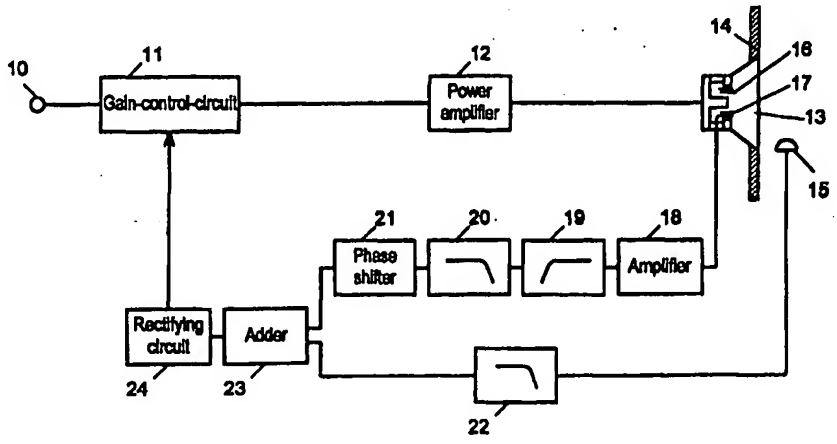
(72) Inventors:
- **ONISHI, Masahide**
  Osaka-shi, Osaka 534-0011 (JP)
- **KONNO, Fumiyasu**
  Hirakata-shi, Osaka 573-0045 (JP)
- **HASEGAWA, Akinori**
  Takasago-shi, Hyougo 676-0822 (JP)

(74) Representative:
Kügele, Bernhard et al
NOVAPAT INTERNATIONAL SA,
9, Rue du Valais
1202 Genève (CH)

(54) SOUND REPRODUCING DEVICE

(57) A signal produced by a speaker is removed from a totaled sound of noise around the speaker and the signal from the speaker, thereby extracting correctly the noise around. This structure allows an audio reproducing apparatus of the present invention to masking compensation more naturally. This audio reproducing apparatus includes a detecting coil (17) disposed on a bobbin (16) of the speaker (13), and a microphone (15) disposed around the speaker (13). An output signal from the detecting coil (17) and an output signal from the microphone (15) are respectively filtered, and then undergo an adding process. An input signal is adjusted its magnitude based on these processed signals.

FIG. 1



EP 1 017 250 A1

Description

Technical Field

[0001] The present invention relates to an audio reproducing apparatus for reproducing a quality signal in a rather noisy environment.

Background Art

[0002] Fig. 8 is a block diagram illustrating a conventional audio reproducing apparatus. In Fig. 8, an input signal received by input terminal 1 is fed into power amplifier 3 via gain-control-circuit 2. An output signal supplied from power amplifier 3 is fed into speaker 4 mounted to baffle 5 and then reproduced. Microphone 6 disposed around speaker 4 collects signals radiated from speaker 4 together with the noises around baffle 5. An output signal supplied from microphone 6 and the output signal from amplifier 3 are fed into subtractor 7, where the input signal component is deducted from the sum of the radiated signal from speaker 4 and the noise around, thereby extracting the noise component around baffle 5. An output signal supplied from subtractor 7 is proportionate to the noise around arid restricts a bandwidth of the noise around via low-pass-filter 8. An output supplied from low-pass-filter 8 is converted from ac to dc by rectifying circuit 9 and then supplied to gain-control-circuit 2 disposed at a stage before amplifier 3. This structure allows gain-control-circuit 2 to change automatically an amplitude of an input signal responsive to the noise around speaker 4 so that the signal radiated from speaker 4 can be prevented from being masked by the noise around.

[0003] However, a conventional audio reproducing apparatus produces a difference between a signal component radiated from speaker 4 and that supplied from amplifier 3, thus subtractor 7 cannot completely remove the signal component radiated from speaker 4. Therefore, the noise component around the speaker is hard to be extracted, whereby the noises within only a limited bandwidth can be restricted.

Summary of the Invention

[0004] The present invention aims to provide an audio reproducing apparatus that removes a signal radiated from a speaker correctly; and changes a gain responsive to noises around.

[0005] In order to achieve this objective, the audio reproducing apparatus of the present invention prepares a microphone disposed around a speaker and a detecting means for detecting a movement of a voice coil of the speaker. The microphone and the detecting means extract a noise component around. This structure allows the noise component around the speaker to be extracted correctly, so that masking compensation can be performed in a natural manner.

Brief Description of Drawings

[0006]

Fig. 1 is a block diagram illustrating an audio reproducing apparatus in accordance with an exemplary embodiment of the present invention.
Fig. 2 shows characteristics of an output from a detection coil of the apparatus.
Fig. 3 shows characteristics of an output from a high-pass-filter of the apparatus.
Fig. 4 shows characteristics of an output from a first low-pass-filter of the apparatus.
Fig. 5 shows characteristics of an output from a microphone of the apparatus.
Fig. 6 shows characteristics of an output from a second low-pass-filter of the apparatus.
Fig. 7 shows characteristics of an output from a phase shifter of the apparatus.
Fig. 8 is a block diagram illustrating a conventional audio reproducing apparatus.

Detailed Description of Exemplary Embodiment

(Exemplary Embodiment 1)

[0007] The exemplary embodiment of the present invention is demonstrated hereinafter with reference to the accompanying drawings.

[0008] Fig. 1 is a block diagram illustrating an audio reproducing apparatus in accordance with the exemplary embodiment of the present invention. In Fig. 1, a signal fed into input terminal 10 is supplied to gain-control-circuit 11, which is controlled by a signal responsive to noises around. This signal is detailed later. An output from gain-control-circuit 11 is fed into power amplifier 12, and an output signal from amplifier 12 is supplied to speaker 13 mounted to baffle 14. Microphone 15 is disposed ahead of speaker 13, thereby collecting a signal radiated from speaker 13 together with the noise around and ahead of speaker 13. Further, in speaker 13, detecting coil 17 is provided to bobbin 16 on which voice coil is wound. Detecting coil 17 outputs a signal proportionate to a vibration speed of the voice coil. An output of detecting coil 17 is amplified by amplifier 18, then the output undergoes high-pass-filter 19 and a first low-pass-filter 20, thereby obtaining a signal—passing a desirable bandwidth for masking compensation—out of the signal components radiated from speaker 13. Second low-pass-filter 22 extracts noise component from an output of microphone 15. Next, an output of first low-pass-filter 20 undergoes phase-shifter 21 so that this output has a phase reverse to the output of second low-pass-filter 22. An output of phase shifter 21 and the output of second low-pass-filter 22 are both fed into adder 23, whereby the signal component radiated from speaker 13 is removed. As a result, the noise collected by microphone 15 from around and ahead of speaker

13 can be solely taken out. This output from adder 23. i.e. noise component around and ahead of speaker 13, is supplied to rectifying circuit 24 to convert an ac signal to a dc signal, then this dc signal is supplied to gain-control-circuit 11. This structure allows a gain to be automatically changed responsive to the noise around the speaker. Thus more natural masking compensation is expected. This mechanism is further detailed hereinafter.

[0009] Fig. 2 shows characteristics of frequency and phase of an output signal supplied from detecting coil 17. The output signal from coil 17 shows the characteristics proportionate to a vibration speed of bobbin 16 on which a voice coil is wound. In Fig. 2, the phase becomes 0 (zero) degree at the frequency of 87 Hz. Fig. 3 shows characteristics of frequency and phase of an output signal from detecting coil 17. This output signal has run through the secondary high-pass-filter 19 having a 87 Hz cutoff frequency. In Fig. 3, the phase becomes 45 degree at the frequency of 118 Hz. Fig. 4 shows characteristics of frequency and phase of an output signal from detecting coil 17. This output signal has run through the primary first low- pass-filter 20 having 118 Hz cutoff frequency.

[0010] Fig. 5 shows characteristics of frequency and phase of an output from microphone 15. As shown in Fig. 5, a signal radiated from speaker 13 shows the same characteristics as that of the output passed the secondary high-pass-filter. Fig. 6 shows characteristics of frequency and phase of the output signal from microphone 15. This output signal has run through the primary second low-pass-filter 22 of which cutoff frequency is 118 Hz. In Fig. 6, the phase characteristic becomes —180 degree at the frequency of 100 Hz. Fig. 7 shows characteristics of frequency and phase of the output signal from detecting coil 17. This output signal has run through phase shifter 21 which is set for a phase to be 0 degree at the frequency of 100 Hz. As shown in Fig. 6 and Fig. 7, the output signal from detecting coil 17 and that from microphone 15 have the frequency characteristics that pass approximately the same bandwidth, and the phases thereof are reverse with each other. These signals are fed into adder 23 whereby the signal component radiated from speaker 13 is removed. As a result, only the noise collected by microphone 15 from around and ahead of speaker 13 can be taken out.

[0011] In this first embodiment, microphone 15 is disposed around and ahead of speaker 13 on the assumption that the noise source is ahead of the speaker. When the noise source is behind speaker 13, microphone 15 is disposed around and back of speaker 13 so that the masking compensation can be more correctly performed. In this case, the phases of respective signals can be reverse with each other by selecting a coupling method of detecting coil 17 or a type of amplifier 18, and as a result, the same effect can be produced.

[0012] In this first embodiment, a detecting coil is used as detecting means. However, a piezoelectric pick-up producing electric charges responsive to a movement of the voice coil or an element converting the stress change due to the movement of the voice coil into a resistance change can also function as detecting means. In this case, an output from the detecting means and the output from microphone 15 desirably have the same characteristic, i.e. these signals run through the same bandwidth, and are in reverse phases with each other so that the same effect can be produced. In order to realize this mechanism, high-pass-filter 19, first low-pass-filter 20, phase-shifter 21, and second low-pass-filter 22 are desirably adjusted appropriately.

Industrial Applicability

[0013] An output from detecting means of voice coil movement of a speaker and an output from a microphone disposed around the speaker are both filtered so that a signal component supplied from the speaker is removed. Thus only the noise around the speaker is correctly taken out, and this output is converted to a dc signal by a rectifying circuit and then supplied to a gain-control-circuit where a gain can be changed automatically responsive to the noise around the speaker. As a result, audio reproduction free from being masked with the noise around is achievable.

Reference numerals in the drawings

[0014]

10. Input terminal
11. Gain-control-circuit
12. Power amplifier
13. Speaker
14. Baffle
15. Microphone
16. Bobbin
17. Detecting coil
18. Amplifier
19. High-pass-filter
20. First low-pass-filter
21. Phase shifter
22. Second low-pass-filter

23. Adder

24. Rectifying circuit

Claims

1. An audio reproducing apparatus comprising:

   (a) a power amplifier for amplifying an input signal;
   (b) a speaker for reproducing an output signal from said power amplifier, said speaker being mounted to a baffle;
   (c) detecting means for detecting a movement of a voice coil disposed in said speaker;
   (d) a microphone disposed around said speaker;
   (e) an amplifier for amplifying an output signal supplied from said detecting means;
   (f) a bandwidth-passing-means for an output supplied from said amplifier;
   (g) a phase shifter for receiving an output signal from said bandwidth-passing-means;
   (h) adding means for adding electrically an output from said phase shifter and a lower frequency component of an output signal, including a noise around and a signal reproduced by said speaker, from said microphone;
   (i) converting means for converting an ac signal supplied from said adding means into a dc signal; and
   (j) control means for adjusting automatically a magnitude of the input signal responsive to the dc signal supplied from said converting means for preventing a reproduced sound from being masked with noise around said speaker, said control means disposed on an input side of said amplifier.

2. The audio reproducing apparatus as defined in Claim 1 wherein said detecting means is a detecting coil disposed at a bobbin wound with a voice coil of said speaker.

3. The audio reproducing apparatus as defined in Claim 1 or 2 wherein said bandwidth-passing-means comprises a low-pass-filter and a high-pass-filter.

4. The audio reproducing apparatus as defined in Claim 1, Claim 2 or Claim 3 further comprising a low-pass-filter disposed between an input side of said adding means and an output side of said microphone.

5. The audio reproducing apparatus as defined in Claim 1, Claim 2 Claim 3 or Claim 4 wherein said converting means is a rectifying circuit.

6. The audio reproducing apparatus as defined in Claim 1, Claim 2, Claim 3, Claim 4 or Claim 5 wherein said control means is a gain-control-circuit for controlling an amplitude of the input signal responsive to the dc signal supplied from said converting means.

7. The audio reproducing apparatus as defined in Claim 1 wherein said microphone is disposed ahead of said speaker.

8. The audio reproducing apparatus as defined in Claim 1 wherein said microphone is disposed behind said speaker.

FIG. 1

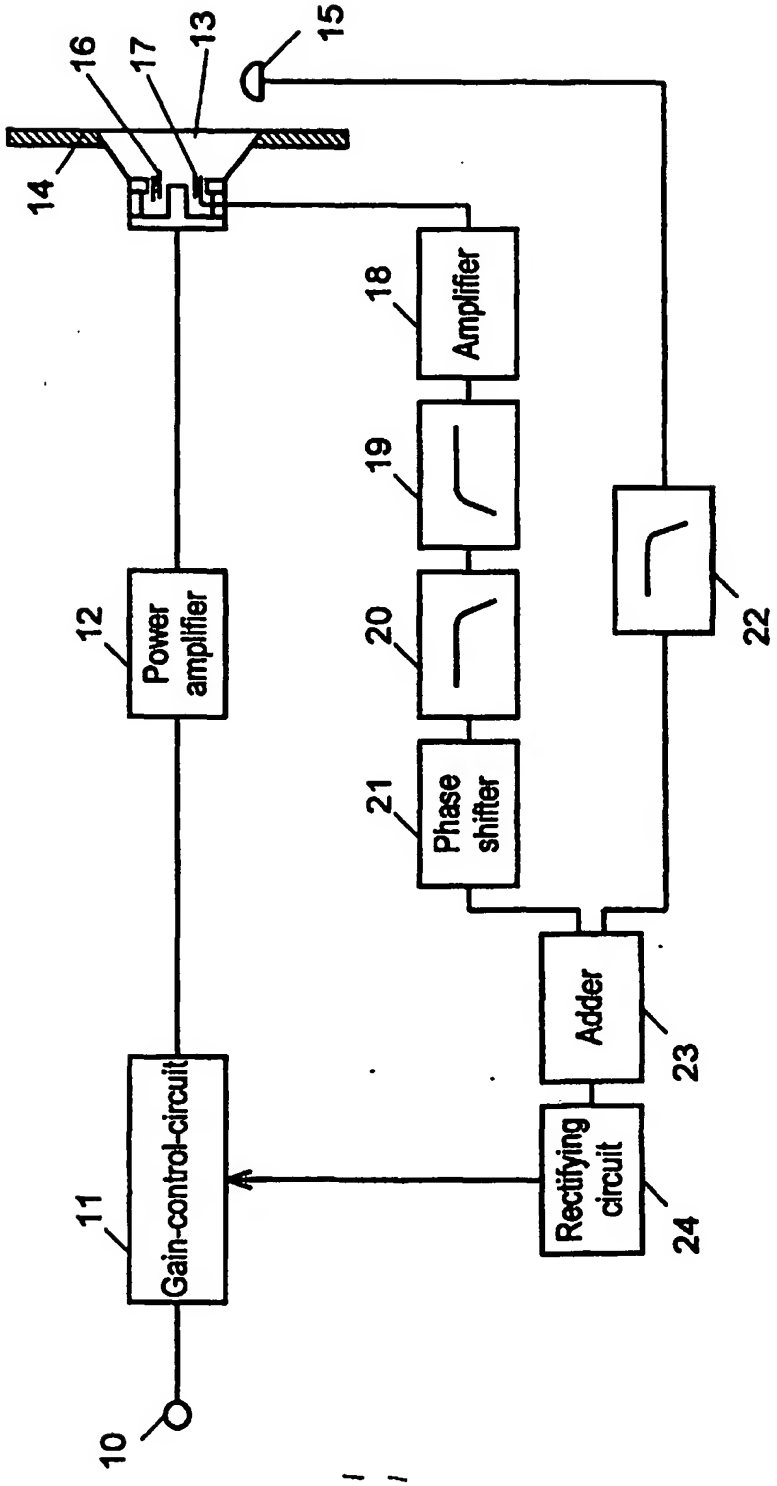

10
11
Gain-control-circuit
12
Power amplifier
13
14
15
16
17
18
Amplifier
19
20
21
Phase shifter
22
23
Adder
24
Rectifying circuit

FIG. 2

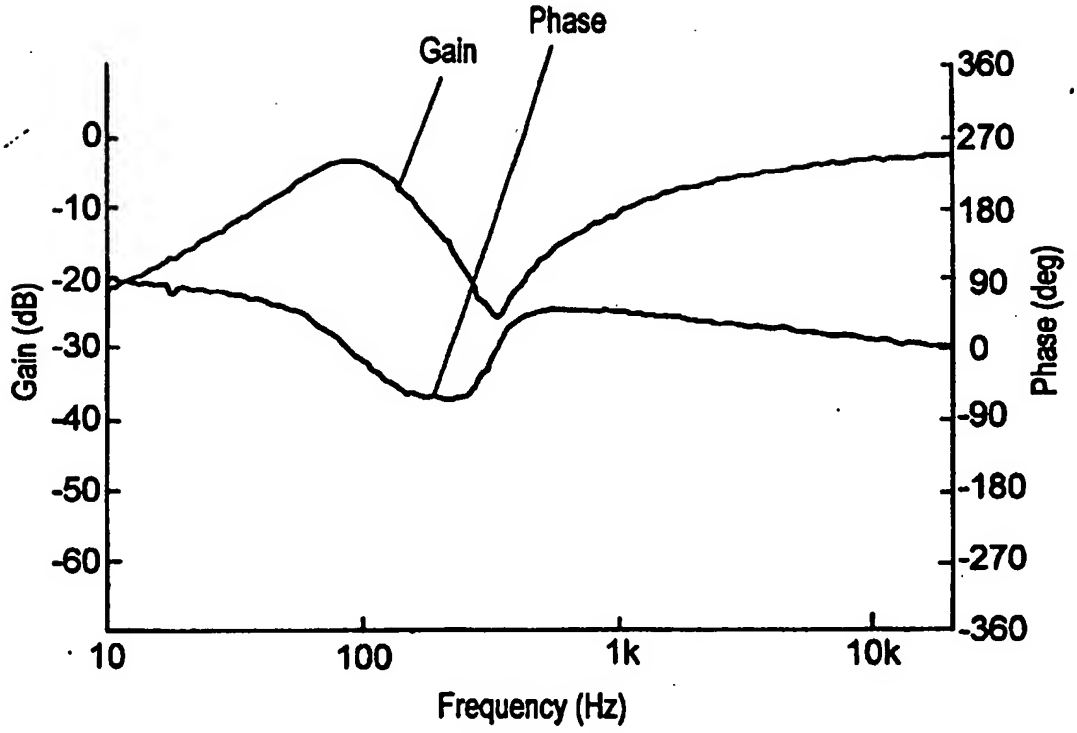

Phase
Gain
0
-10
-20
-30
-40
-50
-60
Gain (dB)
360
270
180
90
0
-90
-180
-270
-360
Phase (deg)
10
100
1k
10k
Frequency (Hz)

FIG. 3

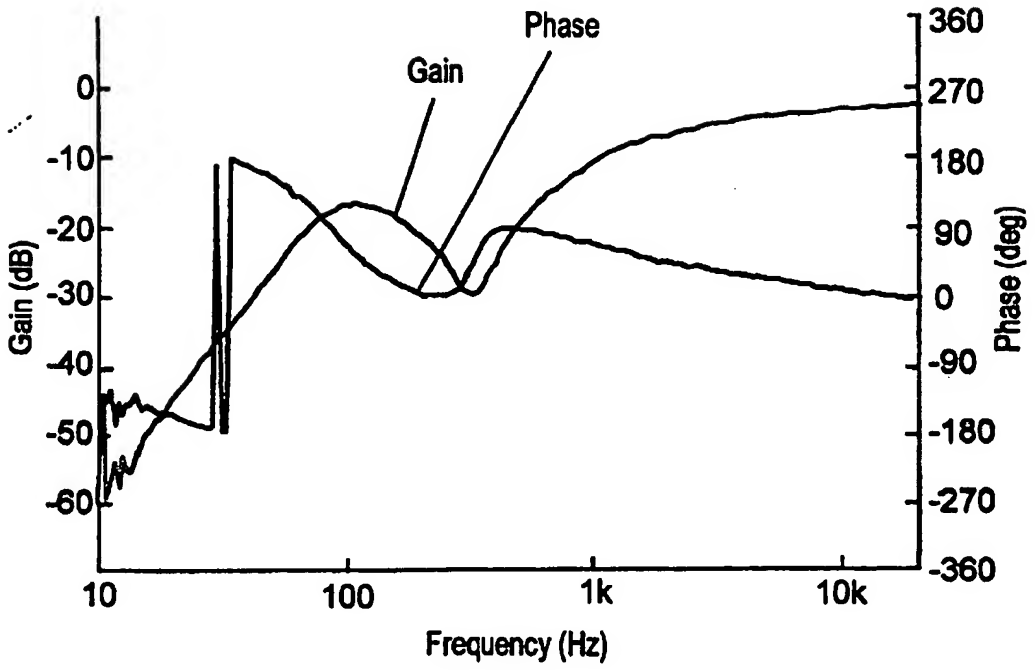

Phase
Gain
0
-10
-20
-30
-40
-50
-60
Gain (dB)
360
270
180
90
0
-90
-180
-270
-360
Phase (deg)
10
100
1k
10k
Frequency (Hz)

FIG. 4

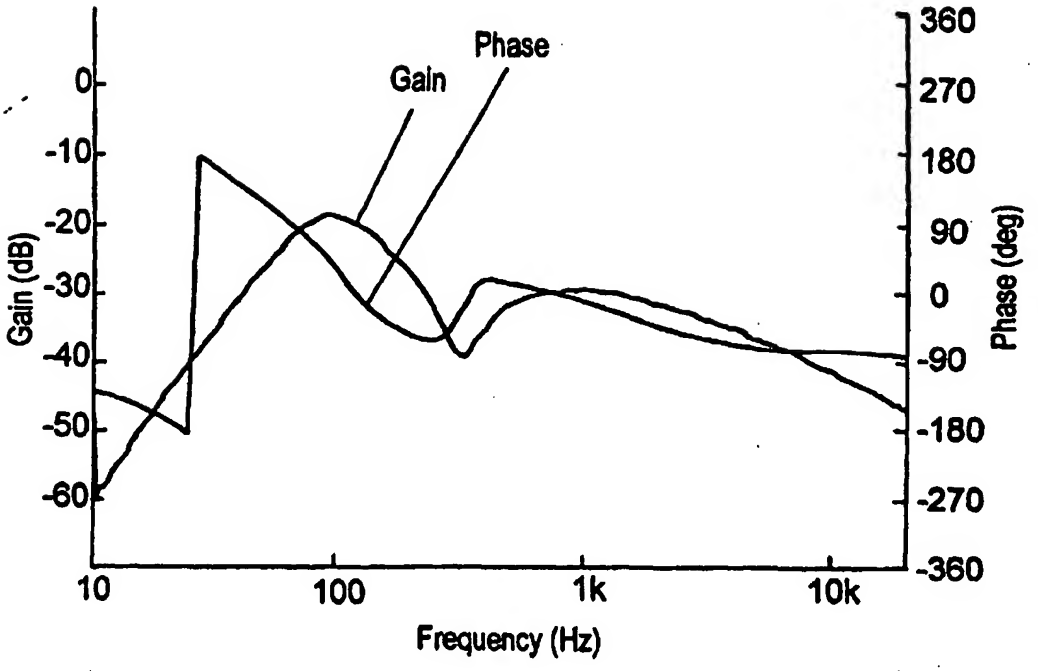

Phase
Gain
0
-10
-20
-30
-40
-50
-60
Gain (dB)
360
270
180
90
0
-90
-180
-270
-360
Phase (deg)
10
100
1k
10k
Frequency (Hz)

FIG. 5

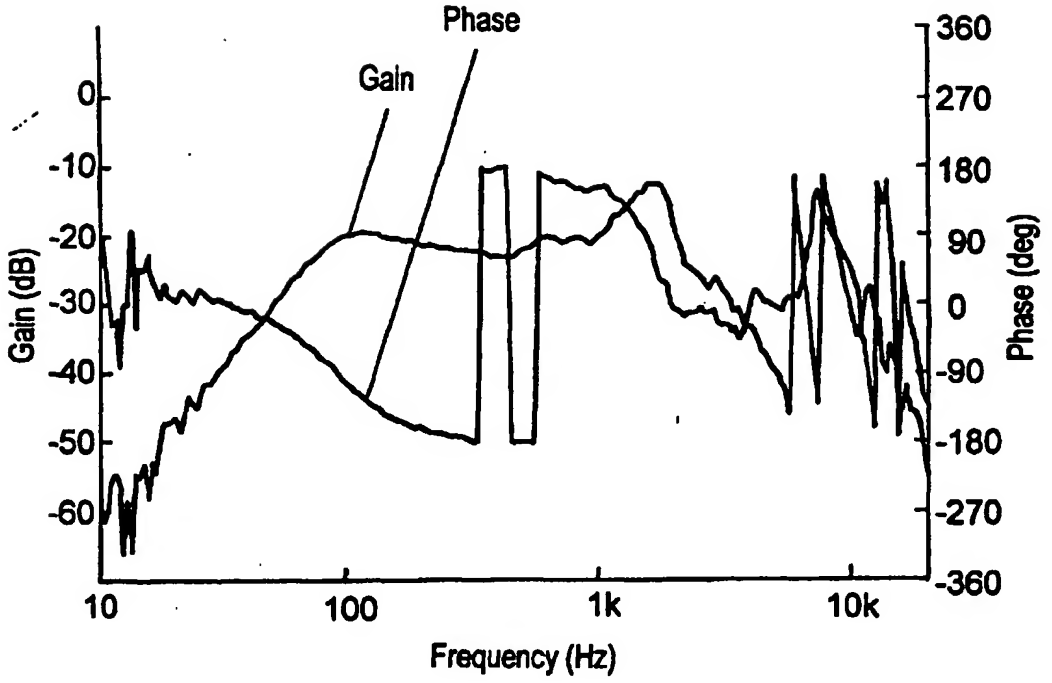

Phase
Gain
0
-10
-20
-30
-40
-50
-60
Gain (dB)
360
270
180
90
0
-90
-180
-270
-360
Phase (deg)
10
100
1k
10k
Frequency (Hz)

FIG. 6

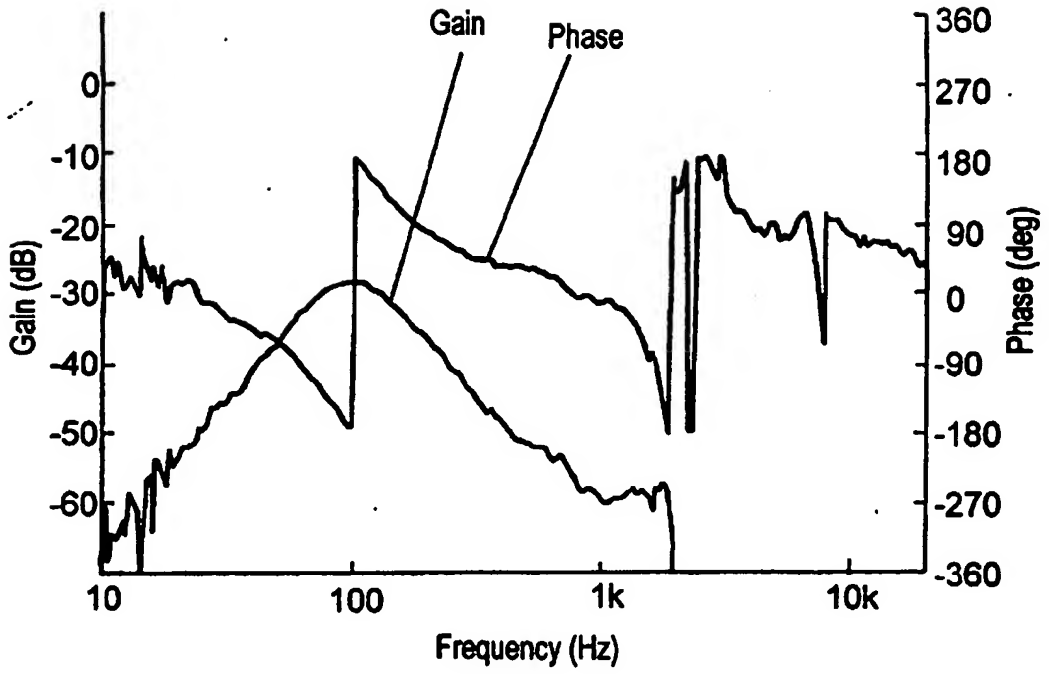

Gain
Phase
0
-10
-20
-30
-40
-50
-60
Gain (dB)
360
270
180
90
0
-90
-180
-270
-360
Phase (deg)
10
100
1k
10k
Frequency (Hz)

FIG. 7

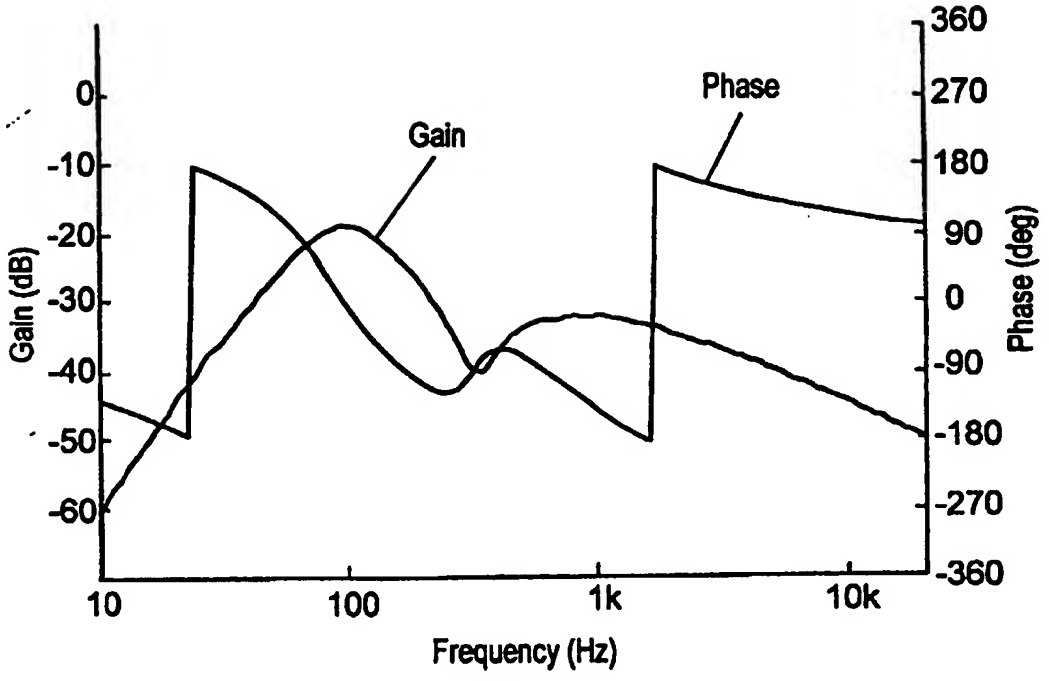
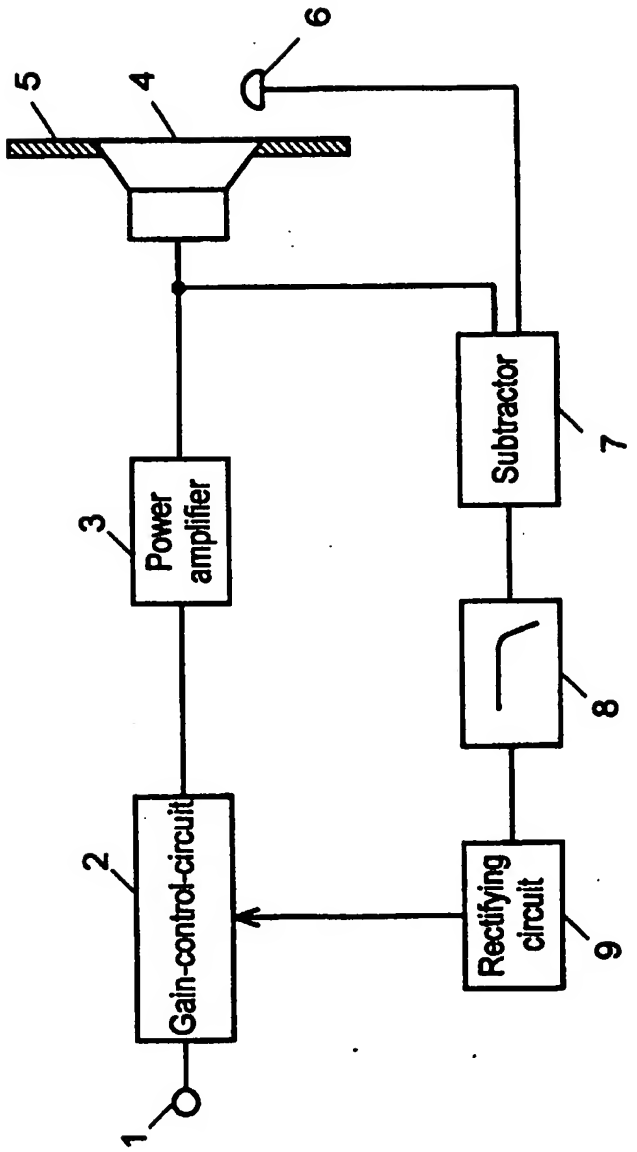

Gain
Phase
0
-10
-20
-30
-40
-50
-60
Gain (dB)
360
270
180
90
0
-90
-180
-270
-360
Phase (deg)
10
100
1k
10k
Frequency (Hz)

FIG. 8


6
5
4
Subtractor
7
3
Power amplifier
8
2
Gain-control-circuit
Rectifying circuit
9
1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP99/03502

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[6] H04R3/00, 310

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[6] H04R3/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1926-1999 Toroku Jitsuyo Shinan Koho 1994-1999
Kokai Jitsuyo Shinan Koho 1971-1999

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, 5-30588, A (Fujitsu General Ltd.), 5 February, 1993 (05. 02. 93), Par. No. [0006] (Family: none)	1-8
Y	JP, 1-282996, A (Citizen Watch Co., Ltd.), 14 November, 1989 (14. 11. 89), Page 3, lower left column (Family: none)	1-8

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 August, 1999 (11. 08. 99)	24 August, 1999 (24. 08. 99)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)